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KINETICS OF DECOMPOSITION OF AMINO ACIDS LABELED WITH C^{14} IN SOILS

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ABSTRACT. The activity of the $C^{14}O_2$ gas phase liberated by decomposition of various amino acids in soil (C^{14} label on carboxyl group) was studied in a sealed chamber with counters at the ends. The reaction rate for the amino acids studied was: methionine > glycine > phenylalanine > valine > alanine. A sharp maximum was observed on each rate curve. The kinetics of decomposition varied inversely with the concentration of the amino acid in the soil; with high concentration (e.g. 100 mg phenylalanine in 90 g soil), a saturation effect occurred.

Earlier [1], a method using hermetic chambers with counters on the ends was /28[1] used to study the kinetics of decomposition of 2-C^{14}-glycine.

In this report, we present the results of a study of the kinetics of decomposition of amino acids labeled with C^{14} in the one position: alanine, glycine, methionine, phenylalanine and valine. The kinetics of the decomposition of the labeled amino acids was also studied as a function of the concentration of amino acids in the soil.

In our experiments we used turf-podzolic moderately loamy soil (horizon A "Dubka" Educational Farm, Moscow Oblast') with the following agrochemical indicators: pH of saline suspension 5.8; hydrolytic acidity 4.1 milliequivalents per 100 g soil; sum of absorbed bases 4.6 milliequivalents per 100 g soil; available phosphorus, after Kirsanov, 12 mg/kg soil; metabolic potassium 60 mg/kg soil; available aluminum 3.3 mg per 100 g soil; total nitrogen 0.10%; organic C 1.2%; hygroscopic moisture content 3.4%.

A charge of 100 g of the air-dry soil was placed in a Petri dish, moistened with water to 25% of the maximum moisture capacity and let stand for 24 hours in order to revive the microbiological activity in the soil.

Then, 100 mg of the labeled amino acid was introduced to the soil in a solution, water was added to 50% of the maximum moisture capacity, and the soil was carefully mixed to provide even distribution of the labeled amino acid. After the soil was spread out in an even layer, the Petri dish containing the soil was placed in a hermetic chamber with counters on the ends and

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[1] Numbers in the margin indicate pagination in the foreign text.

radiometric measurements of the liberation of $C^{14}O_2$ during the process of decomposition of the labeled amino acids was begun.

The course of the kinetics of the liberation of the $C^{14}O_2$ was traced until a constant level of activity of the gas phase in the chamber was reached. The results of the radiometric measurements were used to construct curves of the kinetics of separation of $C^{14}O_2$. At first, the curves were drawn in coordinates of activity (pulses per minute) as a function of time in hours. Then, the maximum activity level reached in each experiment was taken as 100%, and the concentration of $C^{14}O_2$ was expressed as a percentage of the maximum $C^{14}O_2$ activity in each experiment (ϕ). /29

Figure 1 shows the kinetic curves of the liberation of $C^{14}O_2$ in the process of decomposition of various amino acids in the soil. We see that the various amino acids have different curves of the kinetics of decomposition. Figure 2 shows the differential curves of the kinetics of liberation of $C^{14}O_2$, the rate of liberation $d\phi/dt$ being expressed as a function of time t.

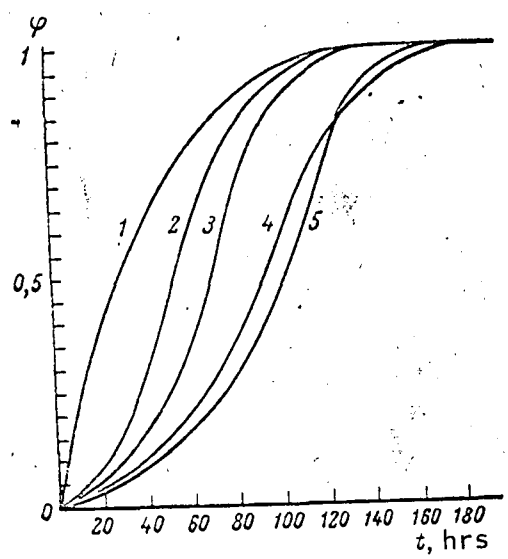

Figure 1. Curves of the Kinetics of Liberation of $C^{14}O_2$ upon Decomposition of Labeled Amino Acids in Soil. 1, Methionine; 2, Glycine; 3, Phenylalanine; 4, Valine; 5, Alanine.

All of the differential curves of the kinetics of liberation of $C^{14}O_2$ show a maximum. The kinetics of decomposition of the labeled amino acids can be characterized by the following indicators: time of termination of decomposition (t_{dec}), time of attainment of maximum rate of decomposition (t_{max}) and the time at which $\phi = 0.5$ ($t_{0.5}$).

This last indicator, apparently, most precisely characterizes the kinetics of decomposition of the amino acids.

As figures 1 and 2 show, the amino acids can be placed in the following series according to the values of $t_{0.5}$ and t_{max}: methionine > glycine > phenylalanine > valine > alanine.

This means that the kinetics of decomposition are most rapid for methionine and slowest for alanine.

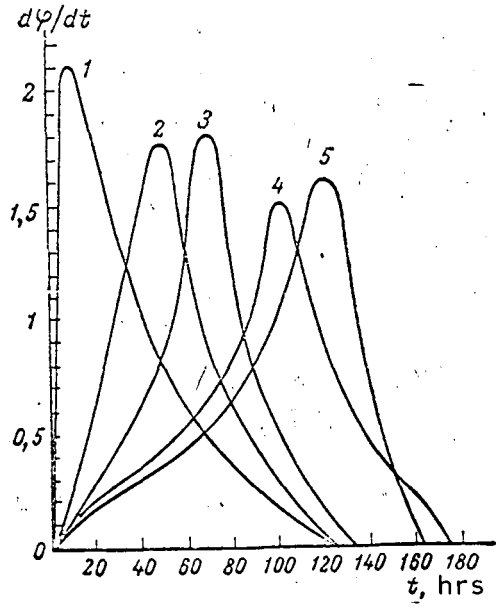

Figure 2. Differential Curves of the Kinetics of Liberation of $C^{14}O_2$ upon Decomposition of Labeled Amino Acids in Soil. 1, Methionine; 2, Glycine; 3, Phenylalanine; 4, Valine; 5, Alanine.

The time of termination of decomposition t_{dec} reflects the specifics of the decomposition of the various amino acids less precisely. For example, the decomposition of methionine, glycine and phenylalanine is completed at approximately the same time, $t_{dec} \approx 120$ hrs, while for valine and alanine $t_{dec} \approx 160$-180 hrs.

It is characteristic that the kinetics of the liberation of $C^{14}O_2$ during the process of decomposition of the amino acids has an "impulse" nature (figure 2). Whether this is actually a characteristic of the decomposition of the amino acids in the soils or whether this result is caused by specifics in our method of studying the kinetics of decomposition of amino acids (the hermetic chamber method) will be shown by further investigation. /30

Figures 3 and 4 show the kinetic curves of the liberation of $C^{14}O_2$ as a function of the relationship between the mass of the soil and the labeled amino acid. Here in one case the mass of the soil was varied with constant mass of amino acid (phenylalanine) while in the other case the mass of the amino acid (also phenylalanine) was varied with constant soil mass.

Analysis of the results produced shows us that a fixed quantity of amino acid is decomposed in different ways by different masses of soil. The following regularity is observed: an increasing mass of soil causes $t_{0.5}$ to decrease approximately linearly.

A fixed mass of soil also decomposes different quantities of amino acid differently.

In this case, apparently due to the limited microbiological activity of the soil, as the concentration of the amino acid in the soil is increased, saturation occurs in the process of decomposition of the amino acid. As we can see from figure 4, the values of $t_{0.5}$ for 100 and 150 mg phenylalanine with 90 g of soil are quite similar.

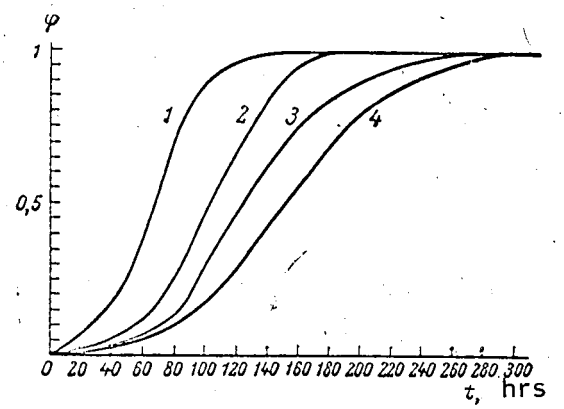

Figure 3. Curves of Kinetics of Liberation of $C^{14}O_2$ upon Decomposition of Predetermined Quantity of Phenylalanine with Various Masses of Soil. 1, 100 g soil + 100 mg phenylalanine; 2, 90 g soil + 100 mg phenylalanine; 3, 60 g soil + 100 mg phenylalanine; 3, 60 g soil + 100 mg phenylalanine; 4, 30 g soil + 100 mg phenylalanine.

Conclusions

1. The method of hermetic chambers with counters in the ends was used to study the kinetics of decomposition of amino acids labeled with C^{14} (label in the carboxyl group) by the liberation of $C^{14}O_2$. In their decomposition rate, the amino acids selected for the experiments can be placed in the following kinetic series: methionine > glycine > phenylalanine > valine > alanine.

2. The kinetics of decomposition of the labeled amino acids have an "impulse" nature; the rate of decomposition first increases, reaches a maximum, then decreases to zero.

3. The kinetics of decomposition of labeled amino acids depend on the concentration of the amino acid in the soil. The greater the concentration of the amino acid in the soil, the less the relative rate of decomposition of the amino acid.

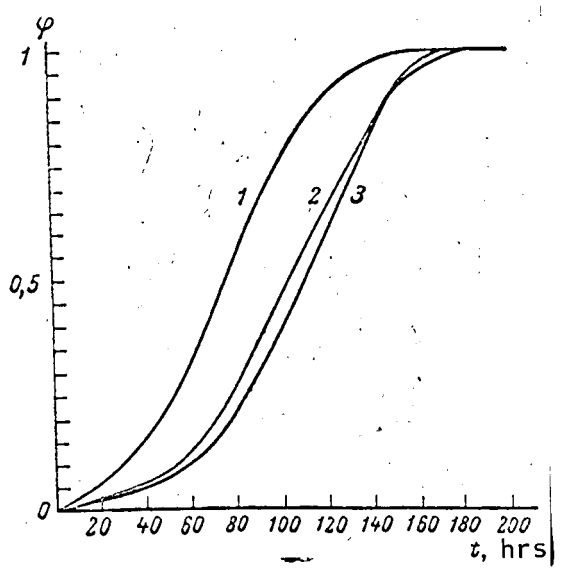

Figure 4. Curves of Kinetics of Liberation of $C^{14}O_2$ upon Decomposition of Phenylalanine in Soil. 1, 90 g soil + 50 mg phenylalanine; 2, 90 g soil + 100 mg phenylalanine; 3, 90 g soil + 150 mg phenylalanine.

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